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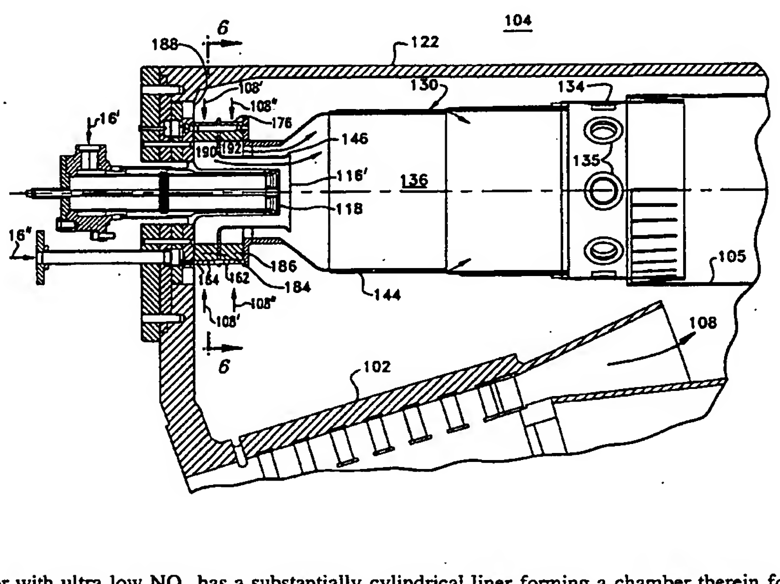

(57) Abstract

A simple combustor with ultra low NO_x has a substantially cylindrical liner forming a chamber therein for containing a combustion zone. The liner does not permit a fuel stream to flow through it and into the combustion zone. The combustor nozzle is centrally disposed in the combustor. A flow guide is disposed between the liner and the fuel nozzle, forming a first inlet passage for the chamber. A first portion of the first inlet passage is formed between the flow guide and the liner and extends axially and is concentric with the liner. A second portion of the first inlet passage extends radially and encircles the first inlet passage first portion. A second inlet passage for the chamber also has two portions. The first portion of the second inlet passage is formed between the fuel nozzle and the flow guide and extends axially and is concentric with the first portion of the first inlet passage. The second portion of the second passage extends radially and encircles the first portion of the second inlet passage.

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ULTRA-LOW NO_x COMBUSTOR

BACKGROUND OF THE INVENTION

The present invention relates to a combustor for burning fuel in compressed air. More specifically, the present invention relates to a low NOx combustor for a gas turbine.

In a gas turbine, fuel is burned in compressed air, produced by a compressor, in one or more combustors. Traditionally, such combustors had a primary combustion zone in which an approximately stoichiometric mixture of fuel and air was formed and burned in a diffusion type combustion process. Additional air was introduced into the combustor downstream of the primary combustion zone. Although the overall fuel/air ratio was considerably less than stoichiometric, the fuel/air mixture was readily ignited at start-up and good flame stability was achieved over a wide range in firing temperatures due to the locally richer nature of the fuel/air mixture in the primary combustion zone.

Unfortunately, use of such approximately stoichiometric fuel/air mixtures resulted in very high temperatures in the primary combustion zone. Such high temperatures promoted the formation of oxides of nitrogen ("NO_x"), considered an atmospheric pollutant. It is known that combustion at lean fuel/air ratios reduces NO_x formation. However, achieving such lean mixtures requires that the fuel be widely distributed and very well mixed into the combustion air.

To reduce the temperatures in the primary combustion zone, and the resulting formation of NO_x, the prior art discloses having primary and secondary combustion zones that receive well-mixed fuel. Referring to prior art Figure 1, a prior art combustor 4 has a primary combustion zone 36 disposed in a

primary section 30 and a secondary combustion zone 37 disposed in a secondary section 32. The primary combustion zone 36 is defined by a liner 44. The liner 44 is surrounded by a liner 42, forming an annular passage 70 for the delivery of cooling compressed air. A liner 40 surrounds the liner 42 in the primary section 30 and defines the secondary combustion zone 37 in the secondary section 32. The liners 40 and 42 form an annular passage 68 having an annular opening 93 between the two combustion zones. Two additional annular passages 90 and 92 are formed between a fuel nozzle 18 and the liner 44 by a flow guide 46 being disposed therebetween.

The prior combustor has means for mixing fuel with compressed air 8 prior to combustion. The primary combustion zone 36 is fed oil fuel 14′ and gas fuel 16′ through a fuel nozzle 18, and is fed gas fuel 16" through fuel tubes 62 in the upstream ends of passages 90 and 92. The gas fuel 16" is well mixed with compressed air 8′ and 8" as it passes through passages 90 and 92 prior to delivery to the primary combustion zone 36. The secondary combustion zone 37 is fed gas fuel 16′" through fuel pegs 76 and oil fuel 14" through fuel spray nozzle 84 disposed in the upstream end of annular passage 68. The fuels 16′" and 14" become well mixed with compressed air 8′" as they pass through the passage 68. The well-mixed fuels enter the secondary combustion zone 37 through the annular opening 93.

Examples of these two-zone combustors are disclosed in U.S. Patent Nos. 5,394,688; 5,408,825; and 5,479,782, all of which are incorporated herein their entireties. Unfortunately, such combustors are complex to manufacture with their two pre-mixing passages and multiple fuel delivery means, resulting in high capital costs. Therefore, a need exists for a simpler combustor that has acceptable NO_x emissions.

SUMMARY OF THE INVENTION

The claimed invention provides a simpler combustor with relatively low NO_x emissions. The combustor has a substantially cylindrical liner forming a chamber therein for containing a combustion zone. The liner does not permit a fuel stream to flow through it and into the combustion zone. The combustor nozzle is centrally disposed in the combustor. A flow guide is disposed

between the liner and the fuel nozzle, forming a first inlet passage for the chamber. A first portion of the first inlet passage is formed between the flow guide and the liner and extends axially and is concentric with the liner. A second portion of the first inlet passage extends radially and encircles the first inlet passage first portion. A second inlet passage for the chamber also has two portions. The first portion of the second inlet passage is formed between the fuel nozzle and the flow guide and extends axially and is concentric with the first portion of the first inlet passage. The second portion of the second passage extends radially and encircles the first portion of the second inlet passage.

BRIEF DESCRIPTION OF THE DRAWINGS

Prior Art Figure 1 is a longitudinal cross-section through a prior art combustor.

Figure 2 is a schematic diagram of a gas turbine employing the combustor of the current invention.

Figure 3 is a longitudinal cross-section through the combustion section of the gas turbine shown in Figure 2.

Figure 4 is a longitudinal cross-section through the combustor shown in Figure 3.

Figure 5 is an isometric view of the air inlet portion of the combustor shown in Figure 3, with the flow guide shown in phantom for clarity.

Figure 6 is a transverse cross-section taken through lines VI-VI shown in Figure 4.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Now referring to the figures, wherein like reference numerals refer to like elements, and in particular to Figure 2, a gas turbine 101 is comprised of a compressor 102 that is driven by a turbine 106 via a shaft 126. Ambient air 112 is drawn into the compressor 102 and compressed. The compressed air 108 is directed to a combustion system that includes one or more combustors 104 and a fuel nozzle 118 that introduces gaseous fuel 116 into the combustor. Other embodiments of the invention may direct oil fuel into the

zone. In the combustors 104, the fuel 116 is burned in the compressed air 108 to produce a hot compressed gas 120.

The hot compressed gas 120 produced by the combustor 104 is directed to the turbine 106 where it is expanded, thereby producing shaft horsepower for driving the compressor 102, as well as a load, such as an electric generator 123. The expanded gas 124 produced by the turbine 106 is exhausted, either to the atmosphere directly or, in a combined cycle plant, to a heat recovery steam generator and then to atmosphere.

Figure 3 shows the combustion section of the gas turbine 101. A circumferential array of combustors 104, only one of which is shown in Figure 3, are enclosed by a shell 122. Each combustor has a single combustion section 130. The hot gas 120 exiting from the combustion section 130 is directed by a transition 105 to the turbine section 106. The hot gas is diluted with compressed air 108 entering the combustor 104 through dilution holes 135 in band 134 that connects the combustor 104 with the transition 105. This is to cool the hot gas 120 since the combustor may run at 2300°F-2900°F preferred embodiment of the invention. The combustion section 130 of the combustor 4 is supported by a support plate 128.

The range of loads that the combustor 104 operates under with relatively low NO_X emissions may be increased with a compressed air by-pass 137. The by-pass 137 directs compressed air out of the shell 122 and back in again to enter the transition 105. A valve 139 in the by-pass 137 controls the compressed air flow by-passing the combustor. The by-pass 137 is different from the dilution holes 135 in the flow of compressed air through the by- pass is controllable. Other embodiments of the invention may have an inlet guide vanes in the compressor 102 to change the flow of compressed air 108 produced and extend the load range of the combustor.

The combustor 104 has a combustion zone 136 located within the combustion section 130, in which burns a lean mixture of fuel and air during operation. Specifically, the combustion zone 136 is enclosed by a cylindrical liner 144. The liner 144 only has provisions for compressed cooling air to flow through it and does not have any means for a fuel/air mixture to flow through

it, such as the annular opening 93 in the prior art combustor 4. Embodiments of the invention may have means for cooling the liner with cooling air such as perforations in the liner, plate fins about the liner, and wiggle strips where the liner meets the band 134.

A fuel nozzle 118 is centrally disposed within the combustion section 130. The fuel nozzle 118 receives and discharges gas fuel 116' into the combustion zone 136. Other embodiments of the invention may discharge oil fuel or both oil and gas fuel through the fuel nozzle.

Compressed air 108 from the compressor 102 is introduced into the combustion zone 136 by an air inlet formed at the combustion section 130's front end. The primary air inlet is formed by first and second passages 190 and 192 that divide the incoming air 108 into two streams 108' and 108". The first inlet passage 190 has an upstream radial portion and a downstream axial portion. The upstream portion of the first passage 190 is formed between a radially extending circular flange 188 and a radially extending portion of a flow guide 146. The downstream portion is formed between the flow guide 146 and the fuel nozzle 118 and is encircled by the second inlet passage 192.

The air inlet's second inlet passage 192 has an upstream radial portion and a downstream axial portion. The upstream portion of second passage 192 is formed between the radially extending portion of the flow guide 146 and a radially extending portion of the inner liner 144. The downstream portion of second passage 192 is formed between the axial portion of the flow guide 146 and an axially extending portion of the inner liner 144 and is encircled by the upstream portion of the passage 192. The upstream portion of the second inlet passage 192 is disposed axially downstream from the upstream portion of first inlet passage 190 and the downstream portion of second inlet passage 192 encircles the downstream portion of the first inlet passage 190.

As shown in Figures 4-6, a number of axially oriented, tubular primary fuel spray pegs 162 are distributed around the circumference of the primary air inlet so as to extend through the upstream portions of the both the first and second air inlet passages 190 and 192. Two rows of gas fuel discharge ports 164 are distributed along the length of each of the primary fuel pegs 162 so

as to direct gas fuel 116" into the air steams 108' and 108" flowing through the inlet air passages 190 and 192. As shown best in Figure 6, the gas fuel discharge ports 164 are oriented so as to discharge the gas fuel 116" circumferentially in the clockwise and counterclockwise directions.

As also shown in Figures 4-6, swirl vanes 184 and 186 are distributed around the circumference of the upstream portions of the air inlet passages 190 and 192 as well. In the preferred embodiment, a swirl vane is disposed between each of the primary fuel pegs 162. As shown in Figure 6, the swirl vanes 184 in the inlet passage 190 impart a counterclockwise (when viewed in the direction of the axial flow) rotation to the air stream 108' so that the air forms a swirl angle B with the radial direction. The swirl vanes 186 in the inlet passage 192 impart a clockwise rotation to the air stream 108" so that the air forms a swirl angle A with the radial direction. The swirl imparted by the vanes 184 and 186 to the air streams 108' and 108" helps ensure good mixing between the gas fuel 116" and the air, thereby eliminating locally fuel rich mixtures and the associated high temperatures that increase NO_X generation. Different embodiments of the invention may have differing amounts of swirler vanes.

In operation, a flame is initially established in the combustion zone 136 by the introduction of gas fuel gas 116', via the central fuel nozzle 118. As increasing load on the turbine 106 requires higher firing temperatures, additional fuel is added by introducing gas fuel 116" via the fuel pegs 162. Since the fuel pegs 162 result in a much better distribution of the fuel within the air, they produce a leaner fuel/air mixture than the central nozzle 118 and hence lower NO_X. Thus, once ignition is established in the combustion zone 136 and the engine has reached the proper load, the fuel to the central nozzle 118 can be shut-off.

As shown in Figures 5 and 6, preferably, the swirl vanes 184 and 186 are oriented in opposition to each other so that the swirl angles A and B tend to cancel each other out, resulting in zero net swirl in the primary combustion zone 36. The optimum angle for the swirl vanes 184 and 186 that will result in good mixing with a minimum of pressure drop will depend on the specific

combustor design and is difficult to predict in advance. Therefore, according to an important aspect of the current invention, the swirl vanes 184 and 186 can be rotated into various angles. The rotatability of the swirl vanes 184 and 186 is achieved being rotatably in pairs along bolts 176. In addition to allowing rotation of the swirl vanes, the alignment bolts 176 serve to clamp the assembly together and provide concentric alignment of flow guide 146 and the liner 144. Details of the operation of the installation and operation of the swirl vanes may be found in the previously incorporated U.S. Patents Nos. 5,394,688 and 5,479,782. Other embodiments of the invention may use non-rotatable swirl vanes or other suitable means for mixing the air and fuel.

The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification, as indicating the scope of the invention.

CLAIMS:

1. In a gas turbine having a compressor for producing a compressed air stream, a combustor for heating the compressed air stream, and a transition for directing the heated compressed air stream to an expander, the combustor comprising:

a) a substantially cylindrical liner forming a chamber therein for containing a combustion zone, said liner having means for preventing a fuel stream from flowing through said liner;

b) a centrally disposed fuel nozzle;

c) a flow guide disposed between said liner and said fuel nozzle forming:

i) a first inlet passage for said chamber having first and second portions, said first inlet passage first portion formed between said flow guide and said liner and extending axially and being concentric with said liner, said first inlet passage second portion extending radially and encircling said first inlet passage first portion; and

ii) a second inlet passage for said chamber having first and second portions, said second inlet passage first portion formed between said fuel nozzle and said flow guide and extending axially and being concentric with said first inlet passage first portion, said second inlet passage second portion extending radially and encircling said second inlet passage first portion.

2. The gas turbine of claim 1 wherein said first and second inlet passages are in flow communication with the compressor, further comprising

a plurality of first swirl vanes disposed in said first inlet passage and a plurality of second swirl vanes disposed in said second passage for imparting a first swirl angle to at least a first portion of said compressed air and a second swirl angle to a second portion of said compressed air.

3. The gas turbine of claim 2 comprising load range adjustment means for enabling the gas turbine to be operated over a range of conditions.

4. The gas turbine of claim 3 wherein said load range adjustment means comprises inlet guide vanes in the compressor.

5. The gas turbine of claim 3 wherein said load range adjustment means comprises by-pass valves in the transition.

6. The gas turbine of claim 2 wherein said liner comprises cooling means for cooling said liner with a first portion of a compressed air cooling stream.

7. The gas turbine of claim 2 wherein said liner comprises dilution means for directing a second portion of said compressed air cooling stream through said liner after said combustion zone.

8. The gas turbine of claim 2, further comprising mean for rotating each of said first and second swirl vanes into at least first and second positions, whereby said first and second swirl angles are adjustable, wherein each of said first vanes is rotatable about a common axis with one of said second vanes.

9. The gas turbine according to claim 8, wherein said first swirl angle opposes said second swirl angle.

10. The gas turbine according to claim 9, wherein said means for rotating each of said first and second swirl vanes, respectively, comprises a plurality of axially oriented shafts, each of said shafts extending through one of said first swirl vanes and through one of said second swirl vanes.

11. The gas turbine of claim 2 further comprising a number of axially oriented, tubular primary fuel spray pegs distributed around a circumference of said first and second inlet passages so as to extend through upstream portions of both said first and second air inlet passages.

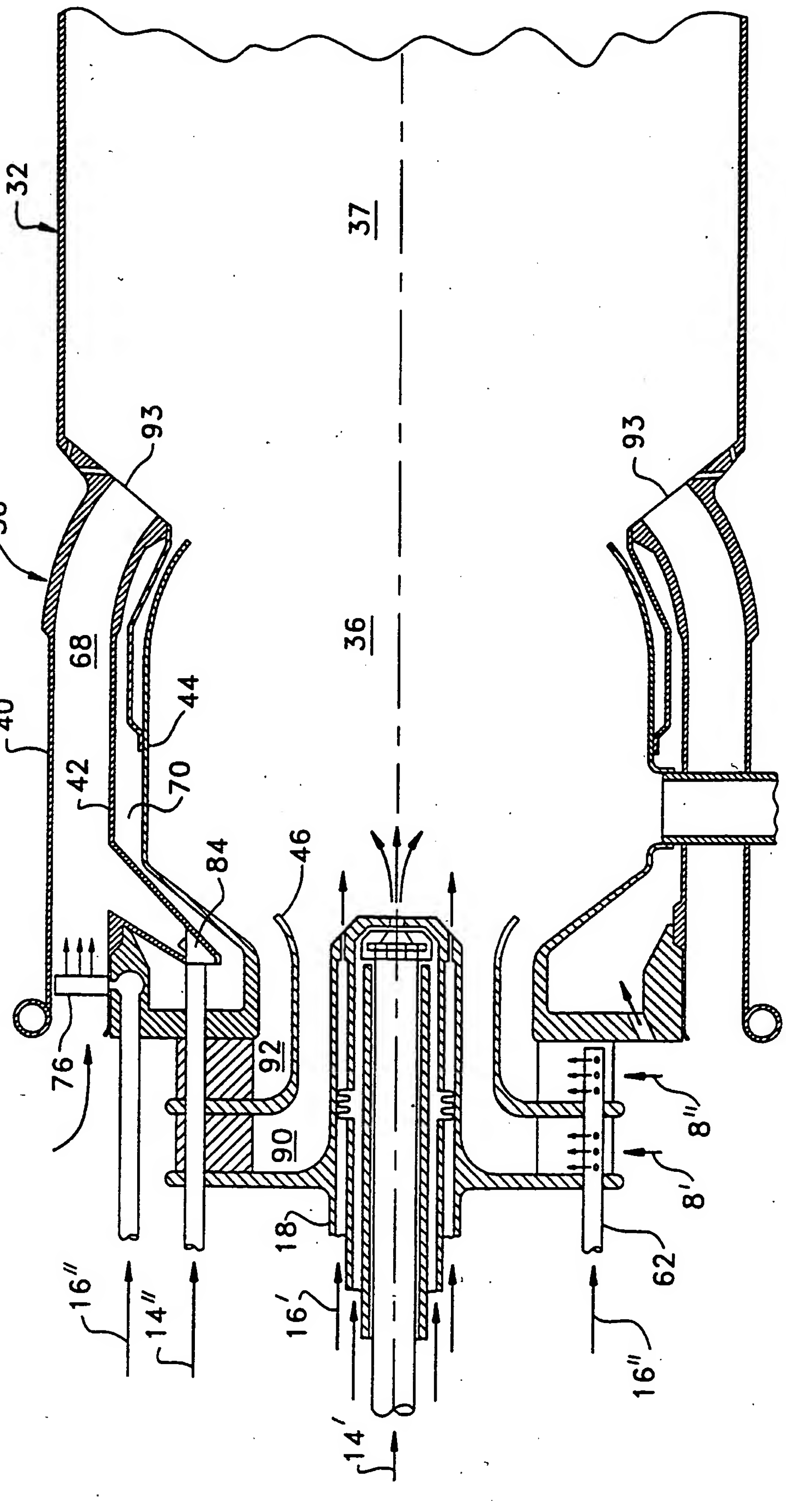

FIG. 1
(PRIOR ART)

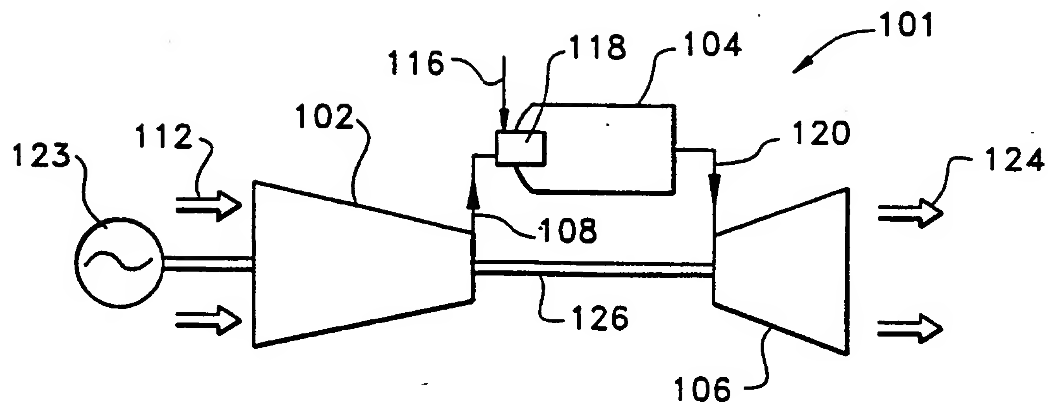
101
116
118
104
102
112
123
120
124
108
126
106

FIG. 2

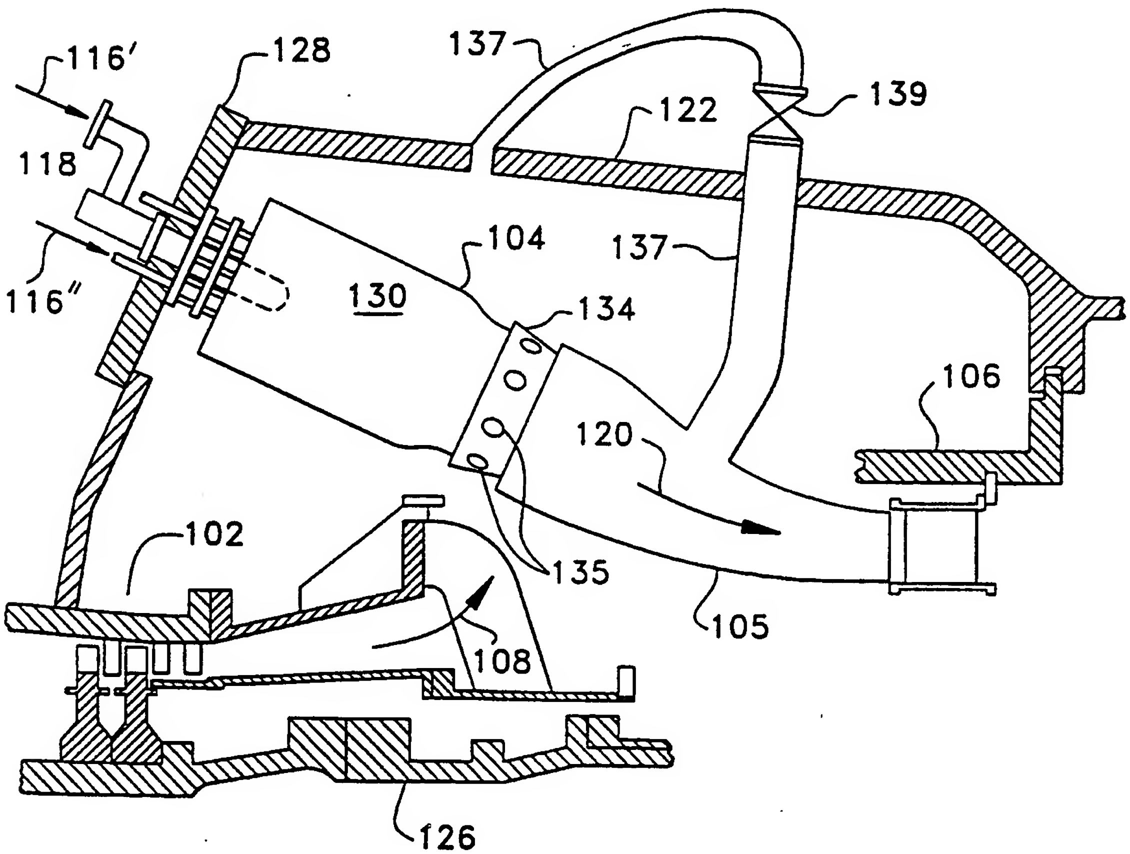
116′
128
137
139
122
118
104
137
116″
130
134
106
120
102
135
105
108
126

FIG. 3

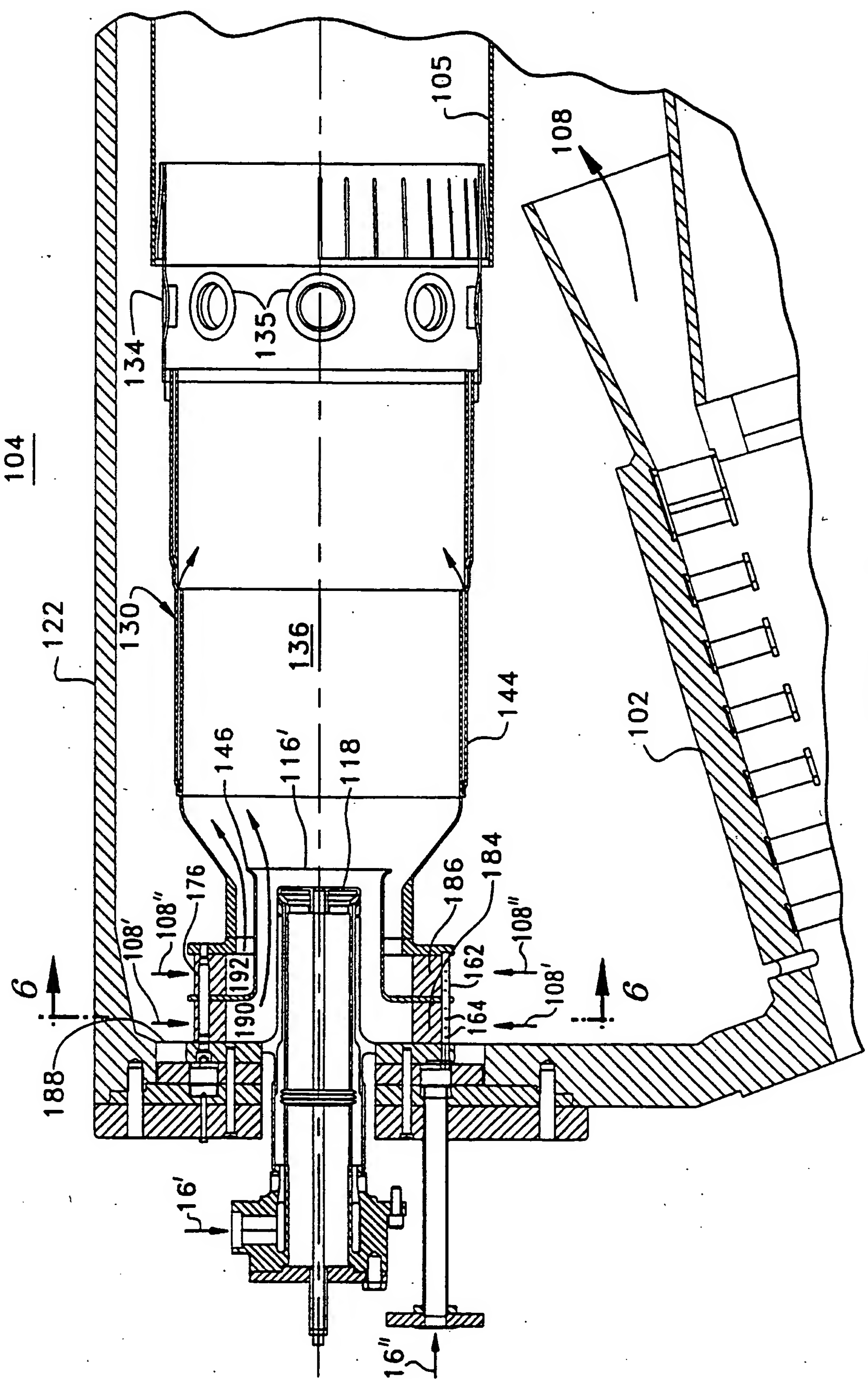
104
105
108
134
135
122
130
136
144
146
116'
118
102
176
108''
108'
192
190
186
184
108''
162
108'
164
108'
6
6
188
16'
16''

FIG. 4

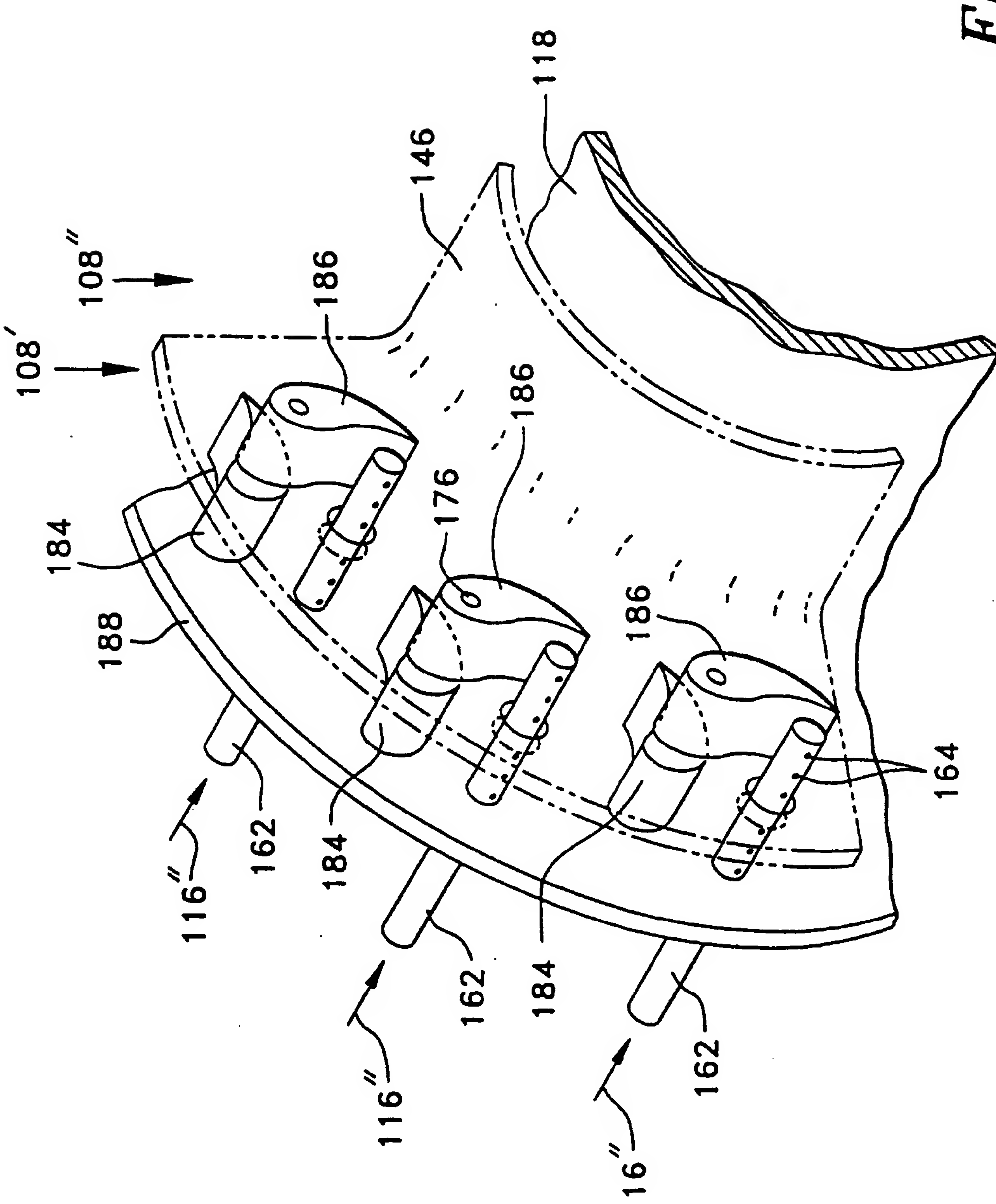
108'
108"
146
118
186
186
176
186
184
188
184
184
164
162
162
162
116"
116"
116"

FIG. 5

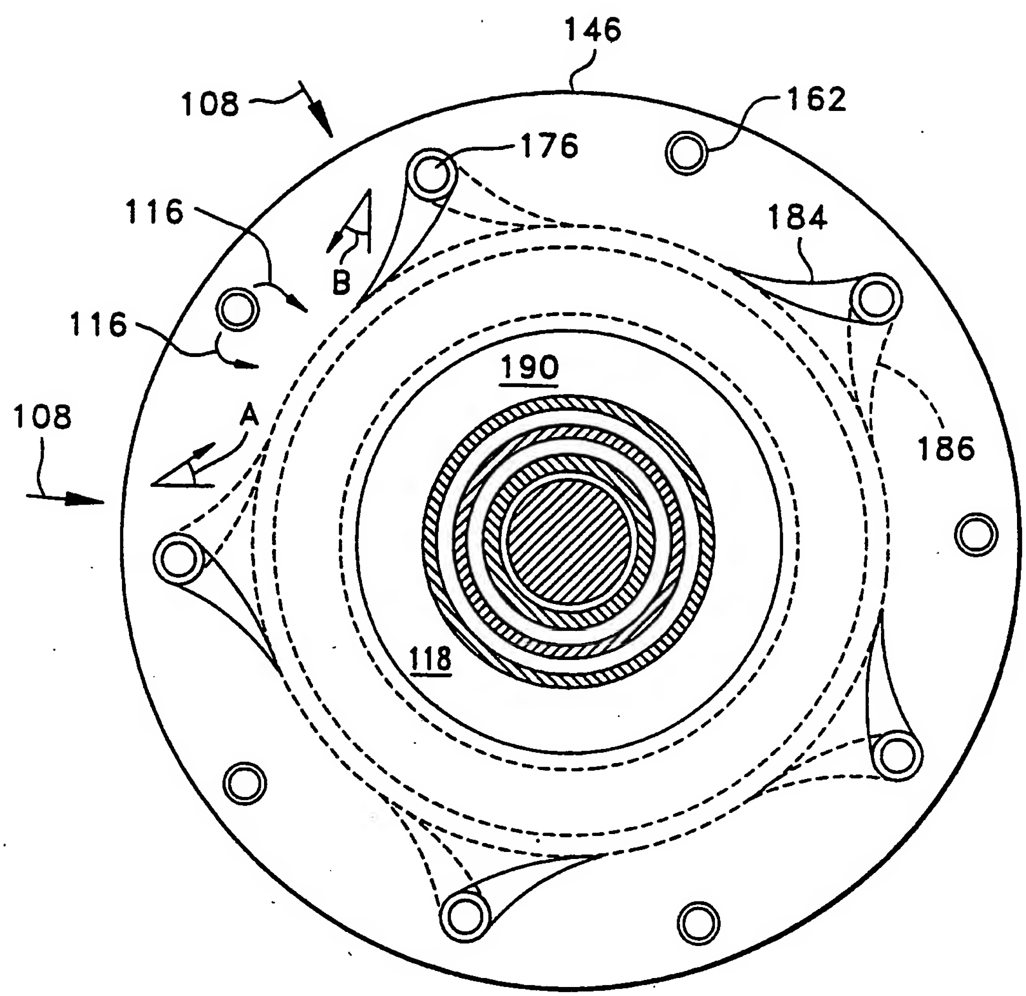

FIG. 6

INTERNATIONAL SEARCH REPORT

Inte[illegible] onal Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F23C7/00 F23D17/00 F23R3/14 F23R3/26 F23R3/34

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B. FIELDS SEARCHED

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IPC 6 F23C F23D F23R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 394 688 A (AMOS DAVID J) 7 March 1995 cited in the application see figure 3 see column 5, paragraph 2 see column 2, paragraph 2 - paragraph 4 see the whole document ---	1-4,6-11
X	US 5 408 825 A (FOSS DAVID T ET AL) 25 April 1995 cited in the application see the whole document ---	1-4,6-11
X	US 5 479 782 A (PARKER DAVID M ET AL) 2 January 1996 cited in the application see the whole document --- -/--	1-4,6-11

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[X] Patent family members are listed in annex.

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26 January 1999	02/02/1999

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INTERNATIONAL SEARCH REPORT

Inter ›nal Application No
PCT/US 98/19869

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 260 382 A (HITACHI LTD ;BABCOCK HITACHI KK (JP)) 23 March 1988 see figures ---	1-4
X	EP 0 469 899 A (GEN ELECTRIC) 5 February 1992 see figures -----	1-3

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte onal Application No
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			KR	9513954	B	18-11-1995
			US	4907962	A	13-03-1990
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